

PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : B63B 39/00, 35/44, E21B 17/01	A1	(11) International Publication Number: WO 98/29298 (43) International Publication Date: 9 July 1998 (09.07.98)
<p>(21) International Application Number: PCT/EP97/07325</p> <p>(22) International Filing Date: 23 December 1997 (23.12.97)</p> <p>(30) Priority Data: 60/034,468 31 December 1996 (31.12.96) US</p> <p>(71) Applicant: SHELL INTERNATIONALE RESEARCH MAATSCHAPPIJ B.V. [NL/NL]; Carel van Bylandlaan 30, NL-2596 HR The Hague (NL).</p> <p>(72) Inventor: ALLEN, Donald, Wayne; 1806 Hillgreen Drive, Katy, TX 77494 (US).</p>		<p>(81) Designated States: BR, GB, ID, MX, NO, OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).</p> <p>Published <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i> </p>
<p>(54) Title: SPAR PLATFORM WITH VERTICAL SLOTS</p> <p>(57) Abstract</p> <p>The present invention is a spar platform (10) having a deck (12) supported by a buoyant tank assembly (22) having a buoyant chamber outside wall (18) and a buoyant chamber inside wall (20) which defines a vertically extending open moonpool (26). A plurality of buoyant chamber side walls connect the buoyant chamber inside and outside walls and defining a plurality of vertical slots (28). A counterweight and a counterweight spacing structure depend from the buoyant tank assembly.</p>		

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece	ML	Mali	TR	Turkey
BG	Bulgaria	HU	Hungary	MN	Mongolia	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MR	Mauritania	UA	Ukraine
BR	Brazil	IL	Israel	MW	Malawi	UG	Uganda
BY	Belarus	IS	Iceland	MX	Mexico	US	United States of America
CA	Canada	IT	Italy	NE	Niger	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NL	Netherlands	VN	Viet Nam
CG	Congo	KE	Kenya	NO	Norway	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NZ	New Zealand	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	PL	Poland		
CM	Cameroon	KR	Republic of Korea	PT	Portugal		
CN	China	KZ	Kazakhstan	RO	Romania		
CU	Cuba	LC	Saint Lucia	RU	Russian Federation		
CZ	Czech Republic	LI	Liechtenstein	SD	Sudan		
DE	Germany	LK	Sri Lanka	SE	Sweden		
DK	Denmark	LR	Liberia	SG	Singapore		

SPAR PLATFORM WITH VERTICAL SLOTS

The present invention relates to a heave resistant, deepwater platform supporting structure known as a "spar." More particularly, the present invention relates to reducing the susceptibility of spars to drag and 5 vortex induced vibrations ("VIV").

Efforts to economically develop offshore oil and gas fields in ever deeper water create many unique engineering challenges. One of these challenges is providing a suitable surface accessible structure. Spars 10 provide a promising answer for meeting these challenges.

Spar designs provide a heave resistant, floating structure characterized by an elongated, vertically disposed hull. Most often this hull is cylindrical, buoyant at the top and with ballast at the base. The 15 hull is anchored to the ocean floor through risers, tethers, and/or mooring lines.

Though resistant to heave, spars are not immune from the rigors of the offshore environment. The typical single column profile of the hull is particularly susceptible to VIV problems in the presence of a passing current. These currents cause vortices to shed from the sides of the hull, inducing vibrations that can hinder 20 normal drilling and/or production operations and lead to the failure of the anchoring members or other critical structural elements.

Helical strakes and shrouds have been used or proposed for such applications to reduce vortex induced vibrations. Strakes and shrouds can be made to be effective regardless of the orientation of the current to 25

- 2 -

the marine element. But shrouds and strakes materially increase the drag on such large marine elements.

Thus, there is a clear need for a low drag, VIV reducing system suitable for deployment in protecting the 5 hull of a spar type offshore structure.

In accordance with the invention there is provided a spar platform comprising:
10 a deck;
a buoyant tank assembly, comprising:
a buoyant chamber outside wall;
a buoyant chamber inside wall defining a vertically extending open moonpool;
a plurality of buoyant chamber side walls, connecting the 15 buoyant chamber inside and outside walls and defining a plurality of vertical slots in the buoyant tank assembly;
a counterweight; and
a counterweight spacing structure.

The invention will be described further in more detail by way of example and with reference to the 20 accompanying drawings in which:

FIG. 1 is a side elevational view of a spar platform in accordance with the present invention;

FIG. 2 is a cross sectional view of the spar platform of FIG. 1, taken at line 2-2 in FIG. 1;

25 FIG. 3 is a side elevational view of another alternate embodiment of a spar platform in accordance with the present invention;

FIG. 4 is a cross sectional view of the spar platform of FIG. 3, taken at line 4-4 in FIG. 3;

30 FIG. 5 is a cross sectional view of the spar platform of FIG. 3, taken at line 5-5 in FIG. 3;

- 3 -

FIG. 6 is a side elevational view of yet another alternate embodiment of a spar platform in accordance with the present invention; and

5 FIG. 7 is a cross sectional view of the spar platform of FIG. 6, taken at line 6-6 in FIG. 6.

In the figures like reference numerals relate to like components.

10 FIGS. 1 and 2 illustrate one embodiment of the present invention. Here spar 10 presents a deck 12 above ocean surface 14. Deck 12 is supported at the top of spar hull 22. The hull is elongated and vertically oriented with a buoyant top section and a ballasted lower section. The hull has an outside wall 18 and an inside wall 20. The inside wall defines a moonpool 26.

15 A plurality of mooring lines 24 are connected to a spread of anchors (not shown) set in the ocean floor to help hold spar 10 in place over wells or subsea manifolds (not shown). In other embodiments, a plurality of risers 16 may act alone as tethers to form the anchoring system 20 securing hull 22 in place while providing conduits for conducting produced oil and gas.

25 Risers 16 extend from the ocean floor to the deck for conducting well fluids from wells or subsea manifold. The upper end of risers 16 are connected to production facilities supported by deck 12 and, after initial treatment, the hydrocarbons are directed through an export riser to a subsea pipeline, not shown. In this embodiment, risers 16 are arranged within moonpool 26 along the interior periphery of hull 22. See also 30 FIG. 2.

Spar 10 is resistant to heave motions and has an elongated, vertically oriented hull 22 which is buoyant at the top, here buoyant tank assembly 21, and is

- 4 -

ballasted at its base, here counterweight 23, which is separated from the top through a middle or counterweight spacing structure 25 . Such spars may be deployed in a variety of sizes and configuration suited to their 5 intended purpose ranging from drilling alone, drilling and production, or production alone.

A basic characteristic of the spar type structure is its heave resistance. However, the typical elongated, usually cylindrical hull or caisson 22 is very 10 susceptible to vortex induced vibration ("VIV") in the presence of a passing current. These currents cause vortexes to shed from the sides of the hull 22, inducing vibrations that can hinder normal drilling and/or production operations and lead to the failure of the 15 risers, mooring line connections or other critical structural elements. Premature fatigue failure is a particular concern.

Prior efforts at suppressing VIV in spar hulls have centered on strakes and shrouds. However both of these 20 efforts have tended to produce structures with having high drag coefficients, rendering the hull more susceptible to drift. This commits substantial increases in the robustness required in the anchoring system. Further, this is a substantial expense for structures 25 that may have multiple elements extending from near the surface to the ocean floor and which are typically considered for water depths in excess of half a mile or so.

The present invention employs a plurality of vertical 30 slots 28 through the buoyant tank assembly 22 which are defined by side walls 29 connecting inner wall 20 and outer wall 18. Slots 28 are aligned in pairs on opposing sides of hull 22. These paired slots allow current to

- 5 -

pass through the spar hull to the moonpool and out again, thereby reducing drag and preventing the highly correlated flow around the hull which leads to VIV problems. The size of the slot, its orientation and configuration may be determined by the specific application. For instance, effectiveness may be increased across a greater angle of attack by the current by beveling, or double beveling the relative orientation of side walls 29 which conduct current through spar 10.

In the embodiment of FIGS. 1 and 2, the vertical slots are aligned to bisect the hull with a flow path directly through the centre of the moonpool and extend substantially the entire length of hull 22. Slots of this length provide an opportunity to pass risers 16 from

an auxiliary drilling and completion vessel (not shown) to the moonpool within the spar. This facilitates use of a smaller, production only spar platform. However, slots of this length may raise particular needs for structural reinforcement. Here a plurality of beams or struts 30 are deployed to join the respective halves of the bisected spar hull 22. Such beams may be used with minimal interference to direct drilling and workover support through the use of auxiliary vessels.

Alternatively, removable struts 32 may join across slots 28 intermittently along the slots. Struts 32 may be removed for riser passing operations. Further, beams 30 and/or removable struts 32 may be formed from substantially open space frames or presented in a streamlined configuration to minimize obstruction.

This reinforcement may be particularly important where more than one pair of slots 28 are deployed. This may be desired to accommodate misalignment of the current to the nominal design orientation. Further, some

- 6 -

locations may have secondary as well as primary design nominal current orientations, e.g., prevalent seasonal shifts.

However, vertical slots 28 need not extend the entire length of hull 22 in order to provide significant drag reduction and VIV suppression. See, e.g., the alternate embodiments of FIGS. 3 and 6. FIGS. 3-5 illustrate an embodiment having two pairs of vertical slots 28A and 28B, here arranged with different azimuth orientations represented by arrows 34 in FIG. 4. Each pair is horizontally aligned, but the pairs need not be on the same level, nor of the same orientation. The two levels here can provide for greater deviation from the nominal design current orientation. Alternatively, a given location may be routinely be subjected to different prevailing currents as a function of depth in the water column. In the later circumstance, different prevailing currents could be optimally addressed with paired vertical slots 28 deployed at various levels which are designed for the orientation, magnitude, and projected variance expected along the spar hull. Note also the riser placement in FIG. 4. Risers too, may be subjected to VIV and the need for VIV suppression within the hull may be controlled by positioning the risers out of alignment with the current path through the moonpool.

Also asymmetrically connected mooring lines may be used to reorient the spar in response to deviations in the current.

FIG. 6 illustrates a configuration of the present invention in which the buoyant tank assembly 21 alone is the hull 22 which defines a buoyant chamber with a pair of slots 28 extending therethrough. A truss or open space frame provides a low drag counterweight spacing

- 7 -

structure 25 connecting counterweight 25 to buoyant tank assembly 21. Further, it should be noted that the moonpool need not be circular, e.g., it may be square or rectangular and the current path may laterally or
5 diagonally bisect the moonpool.

- Other modifications, changes, and substitutions are intended in the foregoing disclosure, and in some instances some features of the invention will be employed without a corresponding use of other features.
10 Accordingly, it is appropriate that the appended claims be construed broadly and in a manner consistent with the spirit and scope of the invention herein.
-

- 8 -

C L A I M S

1. A spar platform comprising:
 - a deck;
 - a buoyant tank assembly, comprising:
 - a buoyant chamber outside wall;
 - a buoyant chamber inside wall defining a vertically extending open moonpool;
 - a plurality of buoyant chamber side walls, connecting the buoyant chamber inside and outside walls and defining a plurality of vertical slots in the buoyant tank assembly;
 - a counterweight; and
 - a counterweight spacing structure.
2. The spar platform in accordance with claim 1, wherein the vertical slots are arranged on opposite sides of the buoyant tank assembly and are aligned through the centre of the moonpool.
3. The spar platform in accordance with claim 2, wherein two said vertical slots are provided and the vertical slots run substantially the length of the buoyant tank assembly.
4. The spar platform in accordance with any one of claims 1-3, further comprising a plurality of removable struts connected across the vertical slots to allow passage of substantially unimpeded current flow when in place and to allow riser passage into the moonpool when temporarily removed.
5. A spar platform in accordance with any one of claims 1-4, further comprising a plurality of struts

- 9 -

- interconnecting the buoyant tank assembly across the substantially open moonpool.
- 5 6. The spar platform in accordance with claim 2 or 3, wherein the vertical slots are arranged in a plurality of horizontally aligned pairs, the vertical slots of each pair being arranged on opposite sides of the buoyant tank assembly and aligned through the centre of the moonpool.
- 10 7. The spar platform in accordance with claim 6, wherein the horizontally aligned pairs of vertical slots are arranged across a plurality of azimuthal orientations.
8. The spar platform substantially as described hereinbefore with reference to the drawings.

1/3

Fig.1.

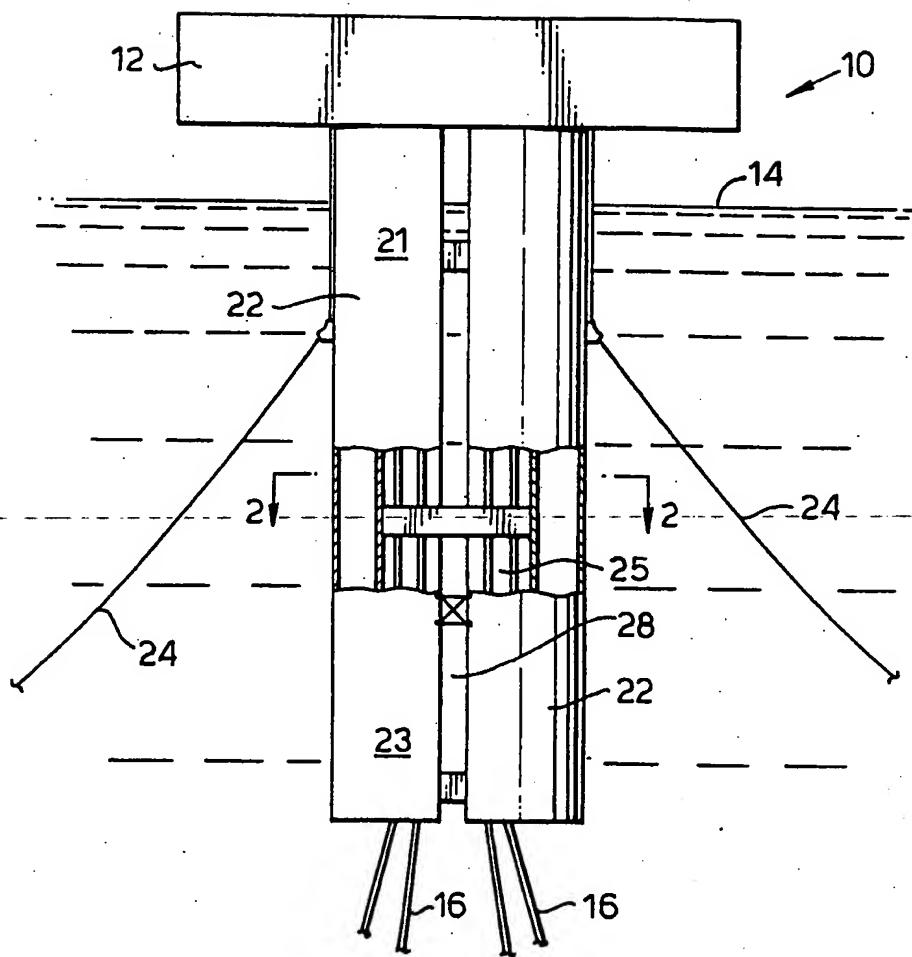
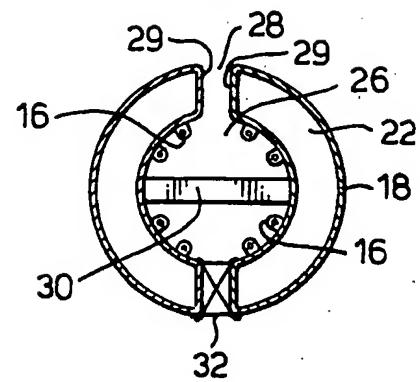


Fig.2.



2/3

Fig.3.

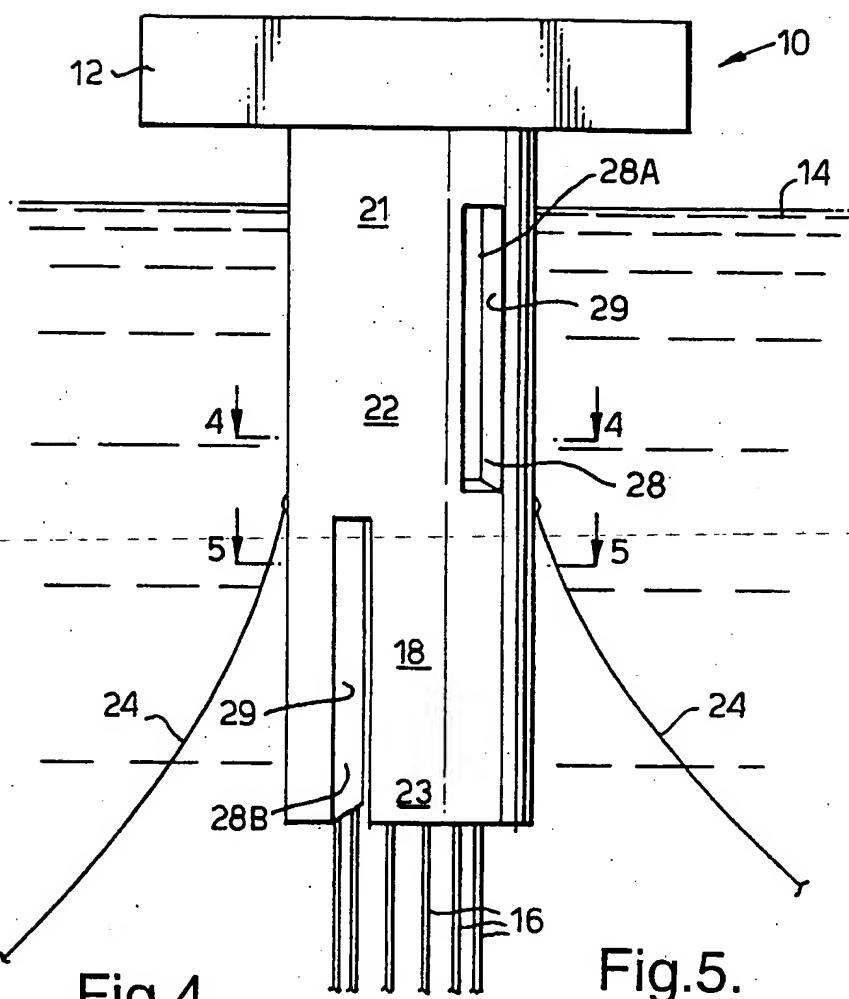


Fig.4.

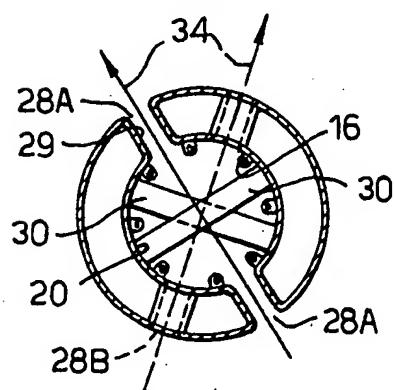
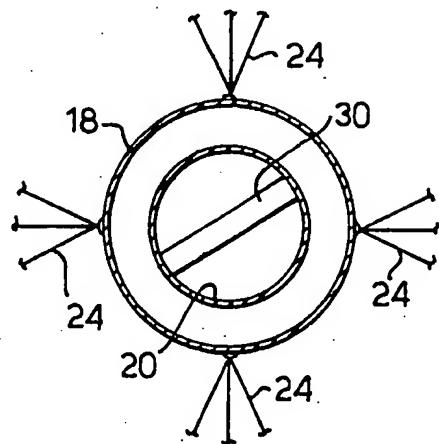


Fig.5.



3/3

Fig.6.

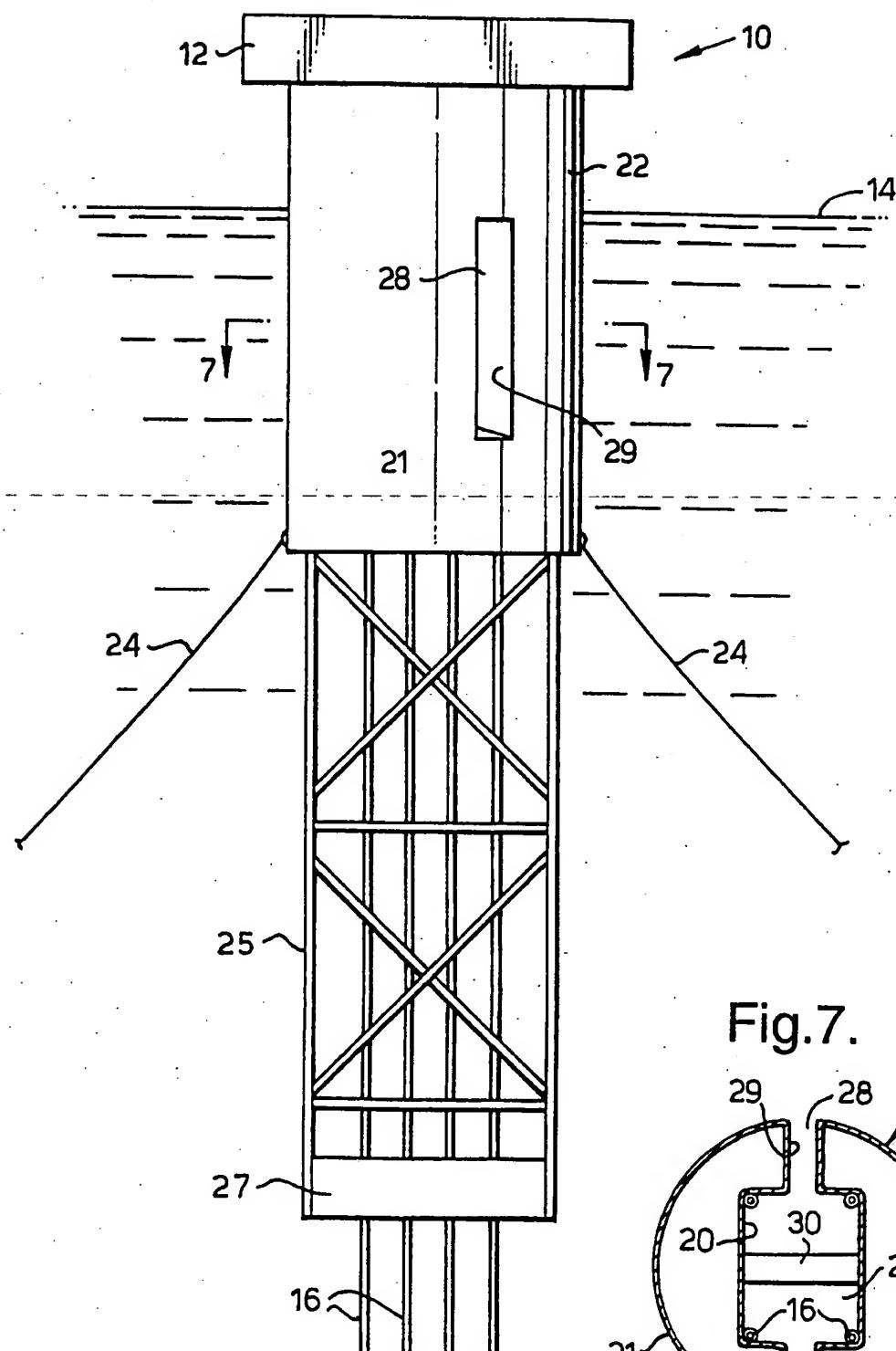
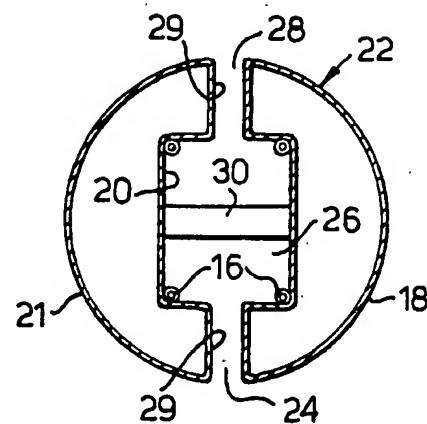


Fig.7.



INTERNATIONAL SEARCH REPORT

International Application No

PCT/EP 97/07325

A. CLASSIFICATION OF SUBJECT MATTER			
IPC 6	B63B39/00	B63B35/44	E21B17/01

According to International Patent Classification(IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 B63B E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3 327 668 A (VON SCHULTZ) 27 June 1967 see column 5, -line 1 -- line 24 ---	1-5,8
X	GB 2 185 446 A (SHELL INTERNATIONALE RESEARCH MAATSCHAPPIJ) 22 July 1987 see page 1, line 60 - line 72 ---	1,2,6-8
X	GB 2 001 587 A (RINALDI) 7 February 1979 see abstract see page 3, line 22 - line 31 see page 3, line 39 - line 46 ---	1,2,6-8
X	US 3 419 090 A (VAN DORN) 31 December 1968 see column 7, line 67 - column 8, line 5 see column 7, line 56 - line 58 ---	1,4,5,8
	-/-	

Further documents are listed in the continuation of box C.

Patent family members are listed in annex.

* Special categories of cited documents :

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

8 May 1998

Date of mailing of the international search report

15/05/1998

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl.
Fax: (+31-70) 340-3016

Authorized officer

Sogno, M

INTERNATIONAL SEARCH REPORT

Int. tional Application No

PCT/EP 97/07325

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 84 01554 A (KWALENER ENGINEERING A.S.) 26 April 1984 see abstract ---	1,8
A	WO 95 26294 A (SHELL INTERNATIONALE RESEARCH MAATSCHAPPIJ) 5 October 1995 see abstract ---	1,8
A	GB 2 061 452 A (MILLER) 13 May 1981 see page 1, line 119 - line 123 ---	1,8
A	US 4 241 685 A (MOUGIN) 30 December 1980 see column 5, line 30 - line 49 ---	1,8
A	US 4 102 142 A (LEE) 25 July 1978 see claim 1 -----	1,8

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/EP 97/07325

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
US 3327668	A	27-06-1967	NONE		
GB 2185446	A	22-07-1987	US	H611 H	04-04-1989
GB 2001587	A	07-02-1979	US	4170954 A	16-10-1979
			AU	530209 B	07-07-1983
			AU	3848178 A	07-02-1980
			CA	1124584 A	01-06-1982
			DE	2831104 A	15-02-1979
			FI	782365 A	02-02-1979
			FR	2399356 A	02-03-1979
			JP	54040493 A	29-03-1979
			NL	7808032 A	05-02-1979
			SE	438647 B	29-04-1985
			SE	7808270 A	02-02-1979
US 3419090	A	31-12-1968	DE	1558965 A	20-08-1970
			GB	1188823 A	22-04-1970
			NL	6709958 A,B	19-01-1968
WO 8401554	A	26-04-1984	AU	2079083 A	04-05-1984
			EP	0122273 A	24-10-1984
WO 9526294	A	05-10-1995	GB	2301648 A	11-12-1996
			NO	964047 A	26-09-1996
GB 2061452	A	13-05-1981	FR	2473654 A	17-07-1981
			US	4505617 A	19-03-1985
US 4241685	A	30-12-1980	FR	2409187 A	15-06-1979
			DE	2845191 A	23-05-1979
			GB	2008513 A	06-06-1979
			JP	54080995 A	28-06-1979
US 4102142	A	25-07-1978	NONE		